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THE ROLE OF SUMMER LEADS IN MELTING SEA ICE

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LONG TERM GOALS

The goal of this project is to understand the role of leads in coupling the atmosphere with the upper Arctic Ocean and its ice cover.

OBJECTIVES

The objective of this project is to understand the processes which control the input of solar energy into summer leads and the disposition of this energy into lateral melting of sea ice, bottom melting of sea ice, and heat storage in the upper ocean. Specifically, we wish to determine: 1) the albedo of lead surfaces as a function of solar altitude, surface roughness, and clouds; 2) optical properties of the upper ocean and their effect on the absorption and penetration of solar radiation; 3) salt and temperature stratification within leads and their dependence on melt rate, air-sea heat exchanges and turbulent mixing forced by the wind and the ice-ocean velocity difference; 4) the heat and fresh-water budgets of leads and the effects of atmospheric, ice and oceanic forcing on components of the budgets; and 5) parameterizations of the input of heat into the upper ocean and the apportionment of that heat into storage and the lateral and bottom melting of sea ice.

APPROACH

We will participate in a summer, (1998) experiment as part of the Surface Heat Budget of the Arctic Ocean (SHEBA) field experiment. The location of the field observations will be in the vicinity of an ice breaker in the Beaufort Sea which has been deployed for the year-long SHEBA experiment. We will make measurements within leads from a 10-m boat and from the edges of ice floes. The measurements will include: 1) incoming and outgoing solar radiation over leads; 2) vertical profiles of temperature, salinity and optical properties at edge sites and on sections across leads; 3) salinity and temperature on a subsurface boom extending forward from the bow of the boat; and 4) velocity in the upper 5 m from small drifters drogued at different depths. The measurements will be analyzed in cooperation with our SHEBA colleagues who have complementary measurements and objectives.

ACCOMPLISHMENTS

Since the beginning of this project in May, 1997, our effort has been concentrated on preparations for the summer 1998. SHEBA lead experiment. We have purchased two, 3-m, fiberglass boats and have outfitted them for measurements in leads. Following local tests, the boats and much of the equipment for our experiment were shipped to the SHEBA field station in the Beaufort Sea aboard the two Canadian icebreakers which established the station.

SCIENTIFIC/TECHNICAL RESULTS

This project began in May, 1997, and we do not yet have results to report. However, a paper describing results from an earlier, related project was published (Pegau et. al., 1996). This paper reported measurements of frazil ice concentration within the water column using optical techniques. Frazil ice particles are formed in supercooled water and are of order 1 mm diameter. The optical instruments were calibrated in the laboratory and frazil ice was measured in Arctic leads during the ONR-supported LEADDEX experiment. The measurements of frazil ice concentration within the water column in the field are believed to be the first-ever.

IMPACT FOR SCIENCE AND SYSTEMS APPLICATIONS

The results from this project are expected to lead to improved parameterizations of the effects of leads-on the reflection, penetration and disposition of solar radiation in circulation models of the ocean and its ice cover. One critical parameterization is the ratio of lateral to bottom melting of sea ice, which determines the strength of an albedo-feedback mechanism. If the lateral melt is large, the fraction of the ocean surface covered by ice decreases rapidly as the summer progresses because the low albedo of leads allows for the absorption of solar radiation and the use of this heat for melting ice. If the lateral melt is small, the fractional area covered by leads remains small and solar heating of the upper ocean is modest.

Measurement of the optical properties of the upper ocean will enable improved predictions of the transmission of light through the upper Arctic Ocean.

The development of optical techniques for the measurement of frazil ice concentrations within the water column is potentially useful for scientific investigations and for practical applications such as assessment of the danger of frazil ice clogging the intake pipes of ships or hydroelectric facilities.

TRANSITIONS

The development of optical techniques for measuring the concentration of frazil ice particles in the water column has lead to the award of an SBIR to Wet Labs Inc. for the design of an instrument which will be commercially available.

RELATED PROJECTS

No related projects apart from those in SHEBA.

PUBLICATIONS

Pegau, W. S., C. A. Paulson, and J. R. Zaneveld, 1996: Optical measurements of frazil ice concentration. *Cold Regions Sci. and Tech.*, 24, 341-353.